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LAND PROTECTION DIVISION  
DEPARTMENT OF ENVIRONMENTAL QUALITY

January 30, 2015

Ms. Hillary Young, P.E.  
Chief Engineer  
Land Protection Division  
Oklahoma Department of Environmental Quality  
707 North Robinson  
P.O. Box 1677  
Oklahoma City, Oklahoma 73101-1677

**RE: Response to Deficiencies  
Seismicity Contingency Plan  
Mid-Way Environmental Services, Inc.  
Non-Hazardous Waste Injection Well  
Permit No. IW-NH-41001-OP**

Dear Ms. Young:

On behalf of our client Mid-Way Environmental Services, Inc. (the Permittee), A & M Engineering and Environmental Services, Inc. is hereby providing responses to the deficiencies in the Seismic Contingency Plan cited by the Oklahoma Department of Environmental Quality (DEQ) in a letter dated December 4, 2014.

**Cited Deficiency:**

**Section 2.0 – Mid-Way states that monitoring of earthquakes will be conducted primarily through the United States Geological Survey (USGS) Earthquake Notification Service. It is recommended that Mid-Way use both the Oklahoma Geological Survey (OGS) and USGS as seismic event data sources.**

**Response:**

Mid-Way Environmental Services, Inc. (Mid-Way) agrees that the OGS event data records provide a current and easily accessible database of earthquakes occurring within Oklahoma. Mid-Way will use both the USGS and OGS databases in monitoring and reporting seismic events.

**Cited Deficiency:**

**Section 3.0 – Mid-Way is proposing steps to ensure mechanical integrity of the injection well in the event of a strong earthquake within the general vicinity of the facility. Mid-Way has defined a strong earthquake as anything greater than 6.0 on the Richter scale. The threshold for action should be defined as anything greater than 4.0 on the Richter scale.**

Response:

In preparing the Seismic Contingency Plan, Mid-Way defined a “strong earthquake” as anything greater than 6.0 on the Richter scale which is consistent with “typical” descriptions used by the USGS for earthquakes of this magnitude. Likewise, when using the Modified Mercalli Intensity scale to describe earthquake intensity, an intensity of VI on the Modified Mercalli scale is described as “strong”.

However, for purposes of ensuring mechanical integrity of the injection well in accordance with Section 3.0 of the Seismic Contingency Plan, Mid-Way agrees to utilize a magnitude of 4.0 or greater on the Richter scale as the threshold for action.

Cited Deficiency:

**Section 4.0 – An increase in the frequency of earthquakes with a magnitude of 1.0 or greater on the Richter scale within a 10 mile radius of the injection well should be tracked and reported to DEQ Quarterly. If the epicenter magnitude of area earthquakes starts to increase, then a reduction in rate and/or injection pressure should be implemented. Also, in the event of a reduction in rate and/or injection pressure, Mid-Way may not resume former operating parameters without permission from DEQ.**

Response:

In order to evaluate what potentially could be considered an increase in earthquake frequency within the DEQ proposed 10-mile radius of reporting; OGS earthquake data for the period of January, 2010 through December, 2014 was tabulated. This five year period precedes any injection by Mid-Way and shows the natural variation in occurrence of earthquakes within the DEQ proposed 10-mile radius of reporting. Attachment 1 presents the tabulated information (by year) on earthquakes within a 10-mile radius of the Mid-Way injection well. Also included for review are a bar chart showing variation in frequency by calendar quarter and a line graph depicting the total number of earthquakes by calendar year.

From the data, it is apparent that the number of earthquakes above a magnitude of 1.0 varies dramatically from year to year. The least number of earthquakes (12) were recorded during calendar year 2010, with the greatest number (47) recorded in calendar year 2012. During calendar year 2014, a total of 19 earthquakes were recorded. All of the earthquakes recorded had a magnitude greater than 1.0 but were below a magnitude of 3.6.

Of the total number of recorded earthquakes (133) for the five year period of review (January, 2010 through December, 2014), 96% of the earthquakes are located 5 to 10 miles away from the MES #1 Injection well. Only four percent (4%) are located between 4 and 5 miles of the injection well. The closest earthquake recorded during the period of review was located approximately 4.07 miles from the MES #1 injection well and had a reported magnitude of 1.4. For the five year period of review, there were no reported earthquakes within 4 miles of the MES #1 injection well.

For purposes of monitoring and implementation of necessary actions, it is proposed that the following thresholds be used:

Radius From Injection Well	Minimum Reporting Magnitude	Action to be Implemented
3 miles	All >1.0 M <sub>L</sub> <sup>1</sup>	None-monitoring/reporting only-track frequency
10 miles	All >1.0 M <sub>L</sub>	None-monitoring/reporting only-track frequency
10 miles	Any >4.0 M <sub>L</sub>	Inspect Piping, Tanks, and Equipment
1 mile	Any >1.0 M <sub>L</sub>	Modification to operating parameters <sup>2</sup>

<sup>1</sup>M<sub>L</sub> – Local Magnitude (Richter Scale)

<sup>2</sup>Once normal operating rate and pressure has been achieved.

In the event operating parameters (rate and injection pressure) are modified due to an increase in earthquake frequency within the radius of review, Mid-Way will obtain concurrence and permission from DEQ prior to resuming normal operating parameters.

#### **Cited Deficiency:**

**Section 6.0 – The response signature of any fall-off test should be compared to prior fall-off tests to confirm that reservoir response is comparable to past tests. Both bottom hole static and flowing pressures should be compared against past data points at a common subsea datum to identify increases in reservoir and operating pressures. In addition Mid-Way should prepare, maintain, and periodically submit a Hall plot with derivatives to DEQ to monitor the well's long term hydraulic behavior using operational data. Hall plots with a derivative function are useful in identifying long term interaction with faults and other reservoir boundaries.**

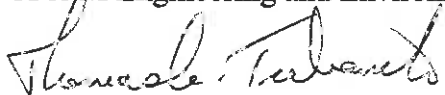
#### **Response:**

When conducting the permit required fall-off testing on the injection well, Mid-Way will gather and provide the requested comparisons to prior fall-off testing using bottom-hole static and flowing pressures at a common subsea datum. In addition, as sufficient data becomes available, Mid-Way will evaluate the injection well's long term hydraulic behavior by periodically submitting Hall plots utilizing the requested derivative functions.

Ms. Hillary Young, P.E.  
January 30, 2015  
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For your review and files, I have attached a revised copy of the Mid-Way Environmental Services, Inc. Seismicity Contingency Plan incorporating the changes discussed. If you have any questions on this matter, or if you require any additional information, please do not hesitate to contact me.

Sincerely,  
A & M Engineering and Environmental Services, Inc.

A handwritten signature in black ink, appearing to read "Thomas A. Trebonik". The signature is fluid and cursive, with the first name "Thomas" being more prominent.

Thomas A. Trebonik, P.G.  
Senior Project Manager

Cc: Ms. Cindy Hailes, DEQ, Letter w/ Attachment Only  
Altay Ertugrul, A&M Engineering, Letter Only  
Turgay Ertugrul, A&M Engineering, Letter Only

## **ATTACHMENT 1**

**Recorded Earthquakes within 10 Miles of MES #1 Injection Well  
Calendar Year 2010**

<b>Number</b>	<b>Date</b>	<b>OGS* ID#</b>	<b>Magnitude (M<sub>L</sub>)**</b>	<b>Approximate Distance from MES #1 Injection Well (Miles)</b>
1	2/19/2010	1901	2.5	5.96
2	5/30/2010	2168	2	5.47
3	9/1/2010	2498	1.5	6.9
4	11/30/2010	2736	1.7	6.73
5	12/10/2010	2879	2	10.02
6	12/10/2010	2916	1.9	10.16
7	12/10/2010	2813	1.7	10.05
8	12/12/2010	2809	2.4	10.14
9	12/13/2010	2883	2.1	10.11
10	12/19/2010	2847	3.6	8
11	12/22/2010	2900	1.5	8.62
12	12/22/2010	2815	1.7	8.93

\*OGS - Oklahoma Geological Survey

\*\*M<sub>L</sub> - Local magnitude (Richter Scale)

**Recorded Earthquakes within 10 Miles of MES #1 Injection Well  
Calendar Year 2011**

<b>Number</b>	<b>Date</b>	<b>OGS* ID#</b>	<b>Magnitude (M<sub>L</sub>)**</b>	<b>Approximate Distance from MES #1 Injection Well (Miles)</b>
1	1/31/2011	3041	2.1	7.07
2	1/31/2011	3099	2.1	6.99
3	3/1/2011	3207	2.2	8.69
4	3/3/2011	3241	1.7	8.52
5	3/16/2011	3182	2	7.66
6	3/16/2011	3206	1.6	7.6
7	3/18/2011	3200	1.9	7.73
8	3/18/2011	3235	2	7.67
9	3/18/2011	3201	2.1	7.16
10	3/20/2011	3210	1.2	7.09
11	4/5/2011	3261	1.6	7.6
12	4/15/2011	3308	2.1	4.66
13	4/22/2011	3271	2.3	8.63
14	4/27/2011	3289	1.7	4.88
15	4/30/2011	3287	1.3	4.72
16	5/2/2011	3380	1.6	5.04
17	5/11/2011	3373	1.8	4.93
18	5/23/2011	3372	2	9.97
19	5/25/2011	3319	1.6	9.29
20	5/25/2011	3376	1.8	10.07
21	10/4/2011	3863	1.9	6.5
22	11/6/2011	6133	3	8.57
23	11/12/2011	6135	1.6	7.89
24	11/16/2011	3955	1.5	9.77
25	11/16/2011	4279	1	10.15
26	11/23/2011	4044	2.2	8.59
27	11/24/2011	14988	3.4	9.79

**Recorded Earthquakes within 10 Miles of MES #1 Injection Well  
Calendar Year 2011**

<b>Number</b>	<b>Date</b>	<b>OGS* ID#</b>	<b>Magnitude (M<sub>L</sub>)**</b>	<b>Approximate Distance from MES #1 Injection Well (Miles)</b>
28	11/24/2011	14955	3.4	9.79
29	11/24/2011	14990	3.4	9.79
30	12/14/2011	4355	1.9	10.19
31	12/19/2011	4308	1.3	9.01

\*OGS - Oklahoma Geological Survey

\*\*M<sub>L</sub> - Local magnitude (Richter Scale)



**Recorded Earthquakes Within 10 Miles of MES #1 Injection Well  
Calendar Year 2012**

<b>Number</b>	<b>Date</b>	<b>OGS* ID#</b>	<b>Magnitude (M<sub>L</sub>)**</b>	<b>Approximate Distance from MES #1 Injection Well (Miles)</b>
1	1/4/2012	4514	1.7	5.53
2	1/16/2012	4537	1.8	8.1
3	1/23/2012	4477	1.2	10.12
4	1/26/2012	4532	1.6	9.34
5	1/26/2012	4471	2	9.41
6	1/26/2012	4515	1.4	9.35
7	1/26/2012	4407	2.1	9.33
8	1/26/2012	4545	2.1	9.37
9	1/26/2012	4406	1.6	9.37
10	1/26/2012	4522	1.8	9.46
11	1/26/2012	4409	1	9.63
12	1/26/2012	15009	3	9.44
13	1/26/2012	4508	3	9.44
14	1/26/2012	4507	2.5	9.39
15	1/26/2012	4466	1.1	9.97
16	1/27/2012	4444	1.8	9.3
17	1/27/2012	4536	1.9	9.21
18	1/27/2012	15010	3	9.27
19	1/27/2012	4489	3	9.27
20	1/27/2012	4456	2.5	9.37
21	1/27/2012	4539	2.4	9.37
22	2/18/2012	4549	2.8	4.48
23	4/28/2012	4720	1.6	10.1
24	5/4/2012	4877	1.5	8.45
25	5/14/2012	4873	1.5	9.32
26	5/29/2012	4789	1.8	7.96
27	6/4/2012	4911	1.5	6.1

**Recorded Earthquakes Within 10 Miles of MES #1 Injection Well  
Calendar Year 2012**

<b>Number</b>	<b>Date</b>	<b>OGS* ID#</b>	<b>Magnitude (M<sub>L</sub>)**</b>	<b>Approximate Distance from MES #1 Injection Well (Miles)</b>
28	6/17/2012	4963	1.1	9.14
29	6/17/2012	4895	2.3	8.58
30	6/19/2012	4943	1.4	5.25
31	7/5/2012	4982	2	9.35
32	7/12/2012	5010	2.1	9.74
33	7/23/2012	4987	1.4	4.07
34	7/31/2012	5035	3.1	10.08
35	8/6/2012	5080	1.9	8.4
36	8/10/2012	5069	2	10.13
37	8/24/2012	5066	1.4	9.29
38	8/25/2012	5044	1.5	7.59
39	8/28/2012	5063	2.3	8.5
40	8/28/2012	5115	1.4	7.73
41	9/7/2012	5168	1.9	10.19
42	9/7/2012	5131	2.1	9.53
43	9/21/2012	5159	1.8	9.83
44	10/24/2012	5204	2.3	10.11
45	11/29/2012	5253	2.2	9.49
46	12/5/2012	5290	1.6	9.76
47	12/14/2012	5343	1.5	9.44

\*OGS - Oklahoma Geological Survey

\*\*M<sub>L</sub> - Local magnitude (Richter Scale)

**Recorded Earthquakes within 10 Miles of MES #1 Injection Well  
Calendar Year 2013**

<b>Number</b>	<b>Date</b>	<b>OGS* ID#</b>	<b>Magnitude (M<sub>L</sub>)**</b>	<b>Approximate Distance from MES #1 Injection Well (Miles)</b>
1	1/25/2013	5428	1.6	8.6
2	2/4/2013	5482	1.5	7.96
3	2/9/2013	8212	1.7	10.1
4	2/27/2013	8216	1.1	6.02
5	4/16/2013	5819	1.5	6.75
6	4/20/2013	8395	1.3	7.04
7	5/26/2013	8677	1.9	6.74
8	5/27/2013	8599	1.5	9.69
9	6/19/2013	8994	2.6	8.87
10	9/18/2013	9553	1.5	9.3
11	9/19/2013	9676	1.8	9.98
12	10/18/2013	7977	1.7	9.92
13	10/19/2013	7501	1.9	9.51
14	10/24/2013	7554	2	9.36
15	11/5/2013	8080	1.9	9.64
16	11/23/2013	8138	1.6	8.58
17	12/8/2013	9779	2.2	9.7
18	12/8/2013	9780	2.6	10.02
19	12/9/2013	9791	2.3	9.74
20	12/13/2013	9842	1.5	9.18
21	12/18/2013	9906	2.2	9.78
22	12/19/2013	9915	1.8	10.05
23	12/25/2013	9941	1.8	9.18
24	12/25/2013	9944	2.3	9.13

\*OGS - Oklahoma Geological Survey

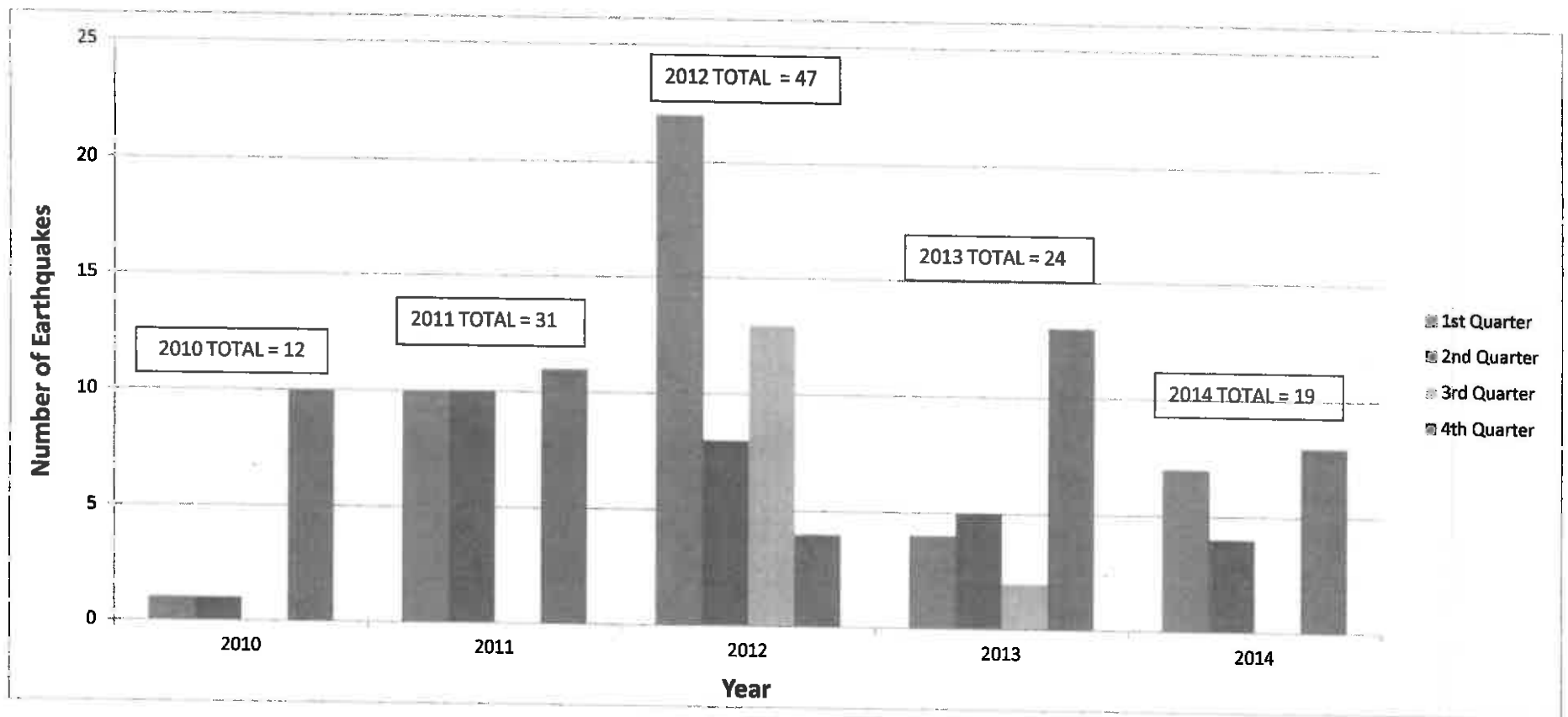
\*\*M<sub>L</sub> - Local magnitude (Richter Scale)

**Recorded Earthquakes within 10 Miles of MES #1 Injection Well  
Calendar Year 2014**

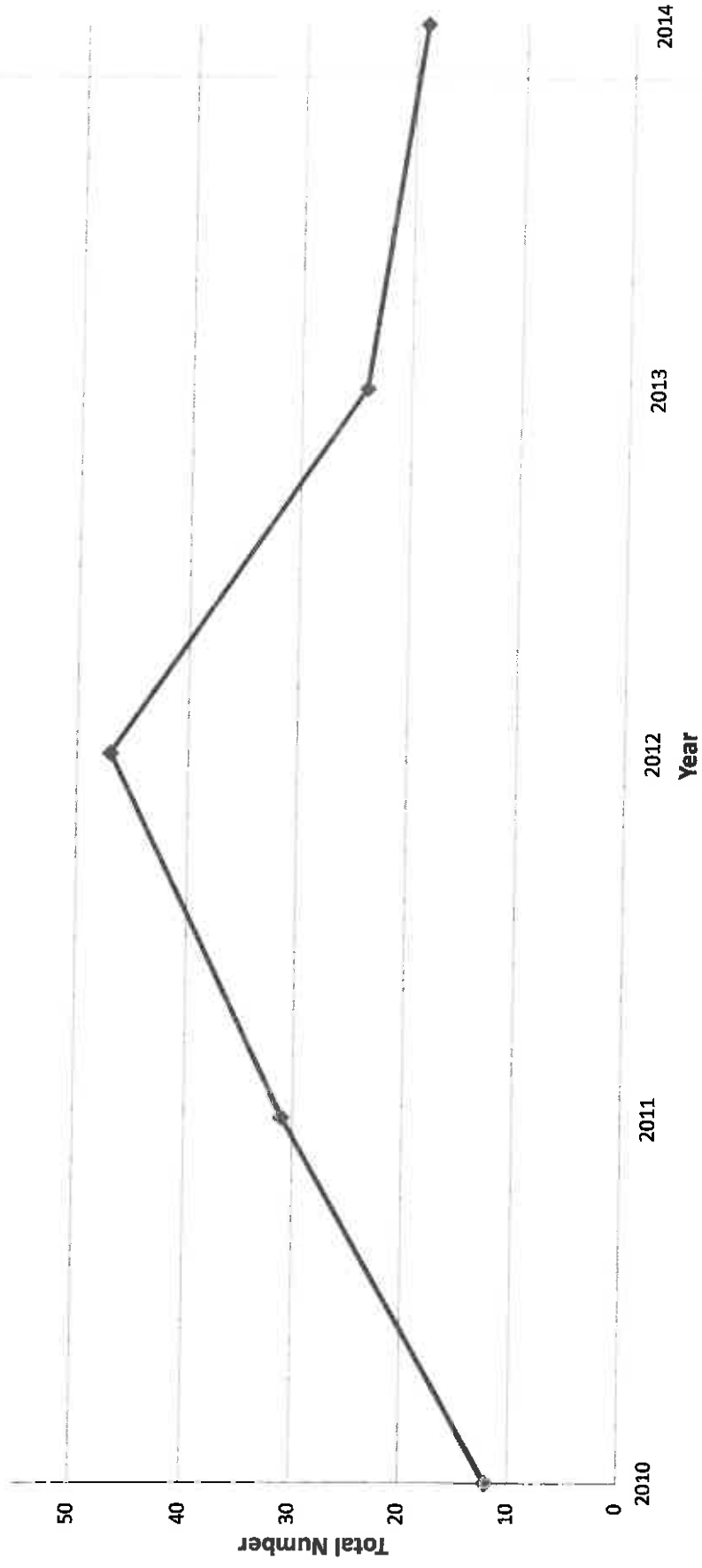
<b>Number</b>	<b>Date</b>	<b>OGS* ID#</b>	<b>Magnitude (M<sub>L</sub>)**</b>	<b>Approximate Distance from MES #1 Injection Well (Miles)</b>
1	1/8/2014	10045	2.9	10.01
2	1/9/2014	10061	3.4	10.16
3	1/10/2014	10077	2.3	9.05
4	1/10/2014	10080	2.6	9.79
5	1/12/2014	10091	1.8	7.98
6	1/16/2014	10139	1.7	9.64
7	3/24/2014	11366	3	8.82
8	5/8/2014	12147	1.8	6.73
9	5/12/2014	12214	2	7.79
10	6/26/2014	12767	2.6	8.87
11	6/27/2014	12771	2.8	9.13
12	11/9/2014	14795	2.3	8.14
13	12/9/2014	15326	2.8	8.08
14	12/9/2014	15346	2.1	8.68
15	12/9/2014	15319	3.5	8.29
16	12/9/2014	15323	2.8	8.12
17	12/12/2014	15440	2.4	7.98
18	12/21/2014	15682	2	8.06
19	12/22/2014	15670	2	8.71

\*OGS - Oklahoma Geological Survey

\*\*M<sub>L</sub> - Local magnitude (Richter Scale)



**Total Earthquakes within 10 miles of MES #1 Injection Well**





**MID-WAY**  
ENVIRONMENTAL SERVICES, INC.

**SEISMICITY CONTINGENCY PLAN**

FOR

MID-WAY ENVIRONMENTAL SERVICES, INC.

CLASS I NON-HAZARDOUS INJECTION WELL

PERMIT NUMBER IW-NH-41001-OP

WITHIN THE N/2 OF THE NE/4 OF THE NW/4 OF THE SW/4

OF

SECTION 9, TOWNSHIP 14 NORTH, RANGE 5 EAST

LINCOLN COUNTY, OKLAHOMA

DATE SUBMITTED: SEPTEMBER 5, 2014

REVISED: JANUARY 2015

PREPARED FOR:

MID-WAY ENVIRONMENTAL SERVICES, INC.

120 NORTH 8<sup>TH</sup> AVENUE

STROUD, OKLAHOMA 74079

SUBMITTED TO:

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

LAND PROTECTION DIVISION

OKLAHOMA CITY, OKLAHOMA

PREPARED BY:

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## **1.0 INTRODUCTION**

Seismic activity is a common occurrence within the State of Oklahoma and earthquake magnitude and frequency is routinely monitored by both the United States Geological Survey (USGS) and the Oklahoma Geological Survey (OGS) through a series of monitoring stations designed to pinpoint the earthquake location and depth. Earthquakes in Oklahoma are typically low in magnitude and relatively shallow in depth with many of the earthquakes too small to be felt.

The majority of earthquakes which occur in Oklahoma are concentrated within a 25-37 mile wide area in western McClain and Garvin Counties. Southeastern Lincoln County, the county in which the Mid-Way Environmental Services, Inc. (Mid-Way) Class I Non-hazardous Waste Injection Well is located, is also known to be seismically active; especially along a segment of the Wilzetta fault which extends in a southwest/northeast direction and crosses southeastern Lincoln County. The Wilzetta fault is one of a series of small faults formed in the Pennsylvanian Epoch (approx. 300 million year ago) during the intra-plate deformation known as the Ancestral Rocky Mountains mountain-building episode. The Mid-Way Environmental Services, Inc. injection well is located approximately 6-7 miles west of the closest point of the Wilzetta fault line as it passes to the east of Davenport and Stroud, Oklahoma

Another fault, the Meers fault, is located in south-central Oklahoma, about 100 km (~62 miles) southwest of Oklahoma City, is the only fault identified in the state with evidence of surface-rupturing earthquakes in the last 3000 years (prior to historical settlement of the region). Paleoseismology studies have identified a temporal clustering of a least three earthquakes on this fault, two of which are dated (1200-2900 years before present) and the third is believed to be older in age.

This Seismicity Contingency Plan has been prepared to identify the methods and procedures for monitoring seismic activity in the area of the Mid-Way Non-hazardous Waste Injection Well facility and is being submitted to the Oklahoma Department of Environmental Quality (DEQ) in accordance with Part A, Item 10 of the Mid-Way Operations Permit.

### **1.1 Purpose**

The purpose of this plan is to identify the methods to be utilized to identify and report to DEQ all earthquakes whose epicenters are within a ten (10) mile radius of the injection well. Earthquakes whose magnitudes are both felt and unfelt by persons living and/or working in the area near the injection well will be recorded and reported. In addition, this Seismicity

Contingency Plan identifies the procedures to be taken by Mid-Way in the event of a major earthquake within the general vicinity of the injection well and facility.

## **2.0 Earthquake Monitoring**

Monitoring of earthquakes will be conducted primarily through the USGS Earthquake Notification Service and Oklahoma Geological Survey. The Earthquake Notification Service is a customizable system that sends automated notification of earthquake activity to an e-mail address and/or linked cell phone. The service can be customized to provide earthquake information on a local, regional, or world-wide basis. In addition, Mid-Way will monitor the Oklahoma Geological Survey (OGS) seismic event data source, OGS news releases, statewide news media and other local media for information on reported earthquakes.

### **2.1 Methodology**

Key facility management personnel will be assigned the responsibility to monitor the occurrence of earthquakes in the general area and to coordinate the appropriate procedures to be followed in the event of a strong earthquake. To effectively monitor the earthquake activity, an account will be established with the USGS Earthquake Notification System to provide information on all earthquakes whose epicenters are within both a three (3) mile and ten (10) mile radius of the injection well. A facility e-mail account will be utilized for receipt of notifications and a database established for recording the notifications. The e-mail account will be linked to facility management cell phones to allow management to receive real time notification of any earthquake events which occur.

### **2.2 Magnitude Monitoring Limitation**

Information for earthquakes in the U.S. is generally available within 5 minutes of the occurrence. Within the United States, USGS typically locates earthquakes down to about magnitude 2.0 on the Richter scale, and about magnitude 4.0 for the rest of the world.

However, for purposes of notification and recording, Mid-Way will request through the Earthquake Notification Service account that all earthquakes within both a three mile and ten mile radius of the injection well having a magnitude of 1.0 or greater be reported to Mid-Way.

Data gathered by USGS indicates that the vast majority of earthquakes recorded in the United States have a magnitude between 2.0 and 5.0 on the Richter scale. Tables 1 and 2 present historic data on earthquakes recorded in the United States during the period of 1990 through 2012. The data indicates that earthquakes having a magnitude below 1.0 are rare, with none

having been reported during the 1990s, and only three (3) having been reported during the period 2000 through 2012. Therefore, limiting the recording level to magnitude 1.0 and above appears reasonable and appropriate.

**Table 1 Number of Earthquakes in the United States for 1990 – 1999\***

<b>Magnitude</b>	<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>	<b>1998</b>	<b>1999</b>
<b>8.0 to 9.9</b>	0	0	0	0	0	0	0	0	0	0
<b>7.0 to 7.9</b>	0	2	2	0	1	0	2	0	0	2
<b>6.0 to 6.9</b>	2	4	15	9	4	6	4	6	3	6
<b>5.0 to 5.9</b>	64	49	72	62	64	45	100	63	62	50
<b>4.0 to 4.9</b>	284	242	404	270	333	350	612	362	411	352
<b>3.0 to 3.9</b>	626	713	1717	1119	1543	1058	1060	1072	1053	1398
<b>2.0 to 2.9</b>	414	559	998	1009	1196	822	654	759	742	814
<b>1.0 to 1.9</b>	1	3	5	7	2	0	0	2	0	0
<b>0.1 to 0.9</b>	0	0	0	0	0	0	0	0	0	0
<b>No Magnitude</b>	877	599	368	457	444	444	375	575	508	381
<b>Total</b>	<b>2268</b>	<b>2171</b>	<b>3581</b>	<b>2933</b>	<b>3587</b>	<b>2725</b>	<b>2807</b>	<b>2839</b>	<b>2779</b>	<b>3003</b>

\*Located by the US Geological Survey National Earthquake Information Center

**Table 2 Number of Earthquakes in the United States for 2000 - 2012\***

<b>Magnitude</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>	<b>2010</b>	<b>2011</b>	<b>2012</b>
<b>8.0 to 9.9</b>	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>7.0 to 7.9</b>	0	1	1	2	0	1	0	1	0	0	1	1	0
<b>6.0 to 6.9</b>	6	5	4	7	2	4	7	9	9	4	8	3	5
<b>5.0 to 5.9</b>	63	41	63	54	25	47	51	72	85	58	89	51	27
<b>4.0 to 4.9</b>	281	290	536	541	284	345	346	366	432	288	631	347	271
<b>3.0 to 3.9</b>	917	842	1535	1303	1362	1475	1213	1137	1486	1492	3584	1838	1236
<b>2.0 to 2.9</b>	660	646	1228	704	1336	1738	1145	1173	1573	2379	4132	2941	2251
<b>1.0 to 1.9</b>	0	2	2	2	1	2	7	11	13	26	39	47	43
<b>0.1 to 0.9</b>	0	0	0	0	0	0	1	0	0	1	0	1	0
<b>No Magnitude</b>	415	434	507	333	540	73	13	22	20	14	12	8	3
<b>Total</b>	<b>2342</b>	<b>2261</b>	<b>3876</b>	<b>2946</b>	<b>3550</b>	<b>3685</b>	<b>2783</b>	<b>2791</b>	<b>3618</b>	<b>4262</b>	<b>8496</b>	<b>5237</b>	<b>3836</b>

\*Located by the US Geological Survey National Earthquake Information Center - (M2.5+; doesn't include US regional network contributions)

**Source** (Table 1 and Table 2): USGS web site (<http://earthquake.usgs.gov/earthquakes/eqarchives/year/eqstats.php>) accessed 8/27/2014.

### **2.3 Recording**

Data received from the USGS Earthquake Notification Service and the OGS seismic event data source on all earthquakes occurring within a ten mile radius of the injection well will be saved into a database designed to provide ease of reporting to DEQ. It is anticipated that the database will be in a spreadsheet format. Data to be recorded will include the date and time of the earthquake; the longitude and latitude coordinates of the earthquake epicenter; depth of the earthquake focus; and reported magnitude. USGS notifications of modification to previously reported earthquake data will also be recorded in the database.

### **2.4 Reporting**

The Mid-Way injection well is located in an area of Oklahoma that is not known to be seismically active and the amount of data to be received from the USGS Earthquake Notification Services is anticipated to be minimal. As such, reporting of earthquake activity within the three and ten mile radii of the injection well will occur on a quarterly basis. The quarterly reporting frequency is consistent with other permit required reporting activities for the injection well. Reporting will include all data gathered and recorded in the database described above.

## **3.0 Additional Seismic Monitoring**

Based on the magnitude and frequency of earthquakes observed during monitoring, and as determined by the DEQ, Mid-Way will conduct additional monitoring through the USGS Earthquake Notification Service and OGS data sources. Mid-Way acknowledges that in the event of a strong earthquake ( $\geq 4.0$  magnitude) within the general vicinity (10-mile radius) of the injection well, additional consideration must be given to ensuring well integrity. Potential impacts from a seismic event of this magnitude may include separation of casing or tubing, casing collapse, and/or open-hole collapse. As a safety precaution, Mid-Way has included in the design of the well, continuous monitoring and recording with automatic shut-down controls to prevent injection of fluids in the event that well integrity is compromised. A Programmable Logic Controller (PLC) system has been designed and implemented at the injection well to monitor and record the entire injection system and initiate alarms and emergency shut-down of injection in the event of abnormal increase or decrease in monitored pressures. Monitoring of well conditions and integrity is designed to detect the potential impacts expected from a strong seismic event as described above. Automated detection of such events enables emergency shut-down interlocks to safely shut-down injection so that the situation can be assessed.

It is currently anticipated that a separate Earthquake Notification Service account will be established by Mid-Way to monitor larger earthquakes within the general vicinity (10 mile radius) of the injection well. This separate account will be customized to monitor earthquakes greater than or equal to a 4.0 magnitude. Recording and reporting of earthquakes of this magnitude ( $\geq 4.0$ ) within the 10 mile radius of the injection well will be similar to the permit required monitoring described in **Section 2.0** above.

During normal business hours and upon notification of a seismic event  $\geq 4.0$  magnitude within the general vicinity, facility personnel will be required to methodically inspect all piping, tanks, and equipment to ensure that no damage has been sustained; no leaks are evident; and all equipment is fully operational. Mid-Way personnel will conduct a visual inspection of the injection pump house, flow equalization tanks, and filter building as outlined above. In addition, Mid-Way personnel will inspect the Waste Storage tanks, pumps and all other piping for leaks.

In the event of notification of a strong earthquake when the facility is closed, facility personnel will be required to methodically inspect all piping, tanks, and equipment *prior to* initiation of injection activities. Facility personnel will be trained on procedures to be followed in the event of notification of a major earthquake in the general area.

Based upon notification of a strong earthquake ( $\geq 4.0$  magnitude) in the vicinity of the injection well *and* a PLC system shut-down condition MES will:

1. Verbally (or through e-mail) notify DEQ of the shut-down condition;
2. Inspect all surface piping and facilities for leaks, verify well head and annulus pressures, and evaluate all PLC components for potential false signals;
3. Notify DEQ whether or not a loss of mechanical integrity is discovered;
4. If no loss of integrity is discovered, DEQ will be notified of system start-up. If loss of mechanical integrity is discovered, a corrective action plan will be developed for DEQ approval;
5. Implement any necessary corrective action;
6. Restore and demonstrate mechanical integrity to the satisfaction of ODEQ prior to resuming the injection of waste fluids.

## **4.0 Modification to Operating Parameters**

Mid-Way is committed to operating the injection well and facility in an environmentally safe and sound manner and recognizes that modification to operating parameters may be necessary if periods of increased seismicity are observed within a one mile radius of the injection well.

In the event that the frequency of earthquakes in the area appears to be increasing within the immediate area of the injection well, Mid-Way will contact the DEQ within 48 hours of the observed increase to discuss the matter. For purposes of this Seismicity Contingency Plan and for DEQ notification purposes, an "increase in frequency" is defined as one (1) or more earthquakes whose epicenter is within a one (1) mile radius of the injection well. Those earthquakes whose magnitude is reported to be  $\geq 1.0$  on the Richter scale will be considered.

Modeling previously conducted on the Mid-Way injection well and provided to DEQ showed that after 10 years of operation with continuous injection at a rate of 11 barrels per minute (bbl/min), the front of injected fluids is estimated to be only 2,100 ft away from the Mid-Way injection well. After 50 years of continuous injection, the front is estimated to be 5,400 ft (approximately one mile) away from the well. The modeled rate is actually greater than the maximum permitted allowable injection rate. As such, utilizing a one mile radius of evaluation to define an "increase in frequency" appears reasonable and appropriate.

Depending on the level of increased seismicity observed, Mid-Way will unilaterally reduce the daily maximum permitted injection volume by 20% until discussions are held with DEQ and agreement to resume injection at the maximum permitted volume is obtained or the increased seismic activity is no longer evident.

During the injection volume reduction period, if no seismic activity above a 1.0 magnitude is recorded within a one mile radius of the injection well over a three consecutive month period, Mid-Way, with permission from DEQ, will resume injection up to the maximum permitted rate and volume.

## **5.0 Additional Geotechnical Information**

Mid-Way recognizes that determination of the cause or causes of an increase in observed seismic activity within a one mile radius of the injection well may require gathering additional operational and geotechnical information. Mid-Way is committed to assisting DEQ in gathering

and evaluating all additional information of the area including but not limited to records of recent petroleum exploration activities in the area, on-going oil and gas production and operating activities, identification of private and commercial salt water injection activities, and other geotechnical information deemed necessary.

## **6.0 Increased Frequency of Well Testing**

Mid-Way further understands that an increase in seismic activity may result in a need for an increased frequency in pressure fall off testing and pressure buildup monitoring within the injection zone at the facility. If conditions warrant, Mid-Way will increase the frequency of pressure fall off testing in accordance with permit requirements from an annual to a semi-annual basis. If semi-annual fall off testing is implemented, Mid-Way will coordinate and obtain agreement from DEQ prior to reverting to annual fall off testing. In addition, as sufficient fall-off testing data becomes available, Hall plots utilizing derivatives will be constructed and used to evaluate the injection well's long term hydraulic behavior.